

Final Project Report to the NYS IPM Program, Agricultural IPM 2003 – 2004

Title:

Providing Growers Local Information on QoI Fungicide Resistance to Guide Fungicide Selection for Cucurbit Powdery Mildew

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Project location(s):

Ontario County, Suffolk County and Lake Plains Counties

Abstract:

Systemic fungicides are an important tool for managing powdery mildew, the most common disease of cucurbit crops throughout the world. Unfortunately, most systemic fungicides are at risk for resistance development because they have single-site mode of action. Thus modification of one gene in the pathogen may be enough to enable the pathogen to resist the action of the fungicide. The cucurbit powdery mildew fungus has demonstrated a high potential for developing resistance. First detections of resistance to QoI (strobilurin) fungicides in North America occurred in 2002 and included New York. Although resistance has developed, QoI fungicides will continue to be valuable for managing powdery mildew and

resistance to DMI fungicide until resistant pathogen strains become common. To use QoIs wisely, growers need to know the proportion of the pathogen population that is QoI resistant before the first application and how much the population changes with QoI use. Through this project, QoI resistant strains were found to be uncommon at the start of disease development. However, where they occurred (Suffolk County), their frequency increased dramatically after QoI and DMI fungicides were used. QoI resistant strains were common in most pumpkin fields examined in September, including 1 of 2 organic production fields examined and a field where neither QoI nor DMI fungicides were used. This information, along with recommendations on how to modify fungicide programs, was provided to growers during the growing season through newsletter articles. Thus growers were able to avoid unnecessary applications of an expensive fungicide during the second half of the epidemic when QoI resistant strains were sufficiently common that QoI fungicides were unlikely to have been effective. Monitoring needs to be continued in the future to determine where QoI resistant strains are sufficiently uncommon that this group of fungicides will be effective. When resistance first developed to DMI fungicides, for several years these resistant strains were uncommon when powdery mildew started to develop, thus these fungicides continued to provide some control.

Background and justification:

Application of fungicides continues to be the principal practice for managing powdery mildew. This is the most common disease of cucurbit crops throughout the world. It occurs every summer throughout the northeastern US. Powdery mildew needs to be controlled on both leaf surfaces to avoid premature death of leaves. It is especially important to control powdery mildew on the underside of leaves where conditions are more favorable for disease development than on upper surfaces. The best approach is to use systemic fungicides. Unfortunately, most systemic fungicides are at risk for resistance development because they have single-site mode of action. Thus modification of one gene in the pathogen may be enough to enable the pathogen to resist the action of the fungicide. The cucurbit powdery mildew fungus has demonstrated a high potential for developing resistance. It has developed resistance to every chemical class at risk for resistance following repeated use somewhere in the world. Presence of resistant strains has been associated with control failure. Thus managing fungicide resistance is an important aspect of effectively managing powdery mildew. The fungicide program that has been recommended is a QoI (aka strobilurin) fungicide (Quadris or Flint) applied in alternation with a DMI fungicide (Nova) tank-mixed with a protectant fungicide. This program uses two strategies for managing resistance: 1. alternation among systemic fungicides in at least two chemical classes and 2. inclusion of protectant fungicides which not at risk for resistance development because they have multi-site mode of action.

Resistance to QoI fungicides was detected in 2002 on Long Island. Resistance resulted in control failure. This was revealed by having Quadris applied alone on a 7-day schedule as one of the treatments in a fungicide efficacy experiment. Quadris was effective initially, providing 80% control of powdery mildew on upper leaf surfaces and 89% control on lower (under) surfaces on August 26 following two applications. But control dropped to 0% (severity not significantly different from nontreated) and 42%, respectively, 8 days later. Quadris applied in alternation with Nova + Bravo provided 75% and 42% control. Isolates were collected and their fungicide sensitivity tested. Control failure was confirmed to be due to resistance.

QoI fungicides will continue to be an important tool for managing powdery mildew until resistance reaches a high level or another chemical class becomes available. Presently there are no other systemic fungicides far enough along in development that they could be requested for use through a Section 18 registration. The DMI fungicide Nova should not be used exclusively when QoI fungicides are effective as this will put an undesirable amount of pressure on the powdery mildew pathogen to select strains able to resist Nova. On the other hand, QoI

fungicides are expensive thus it is undesirable to be applying them when they won't be effective because resistance is at a high level. Additionally, using ineffective fungicides is an unacceptable

To select the best fungicide program, growers need information on the proportion of the pathogen population that is resistant before the first application and the impact on resistance of applying QoI fungicides. This information can be obtained using a seedling bioassay. Results are obtained in just 7 to 10 days. This bioassay was used successfully to monitor the proportion of isolates resistant to Bayleton and Benlate in a previous IPM project. This bioassay entails dipping potted squash seedlings in fungicide solution, then placing them with non-treated seedlings next to field-grown plants with powdery mildew for one day. Early spring-planted summer squash will become infected with powdery mildew before main-season crops. Powdery mildew is a greater concern, having more impact on yield, in main-season crops, which include pumpkin, gourd, winter squash and melon. Therefore the early crops are used to determine the composition of the pathogen population for these important main-season crops. If more than 50% of the population is resistant to QoI fungicides, then QoI fungicides will not be recommended for powdery mildew management. When QoI resistance is at a low level, these fungicides can play an important role in managing resistance to the other important group of systemic fungicides, the DMI fungicides.

Next growers need to know the impact of applying QoI fungicides on resistance. The recommended weekly fungicide program for 2003 was a QoI fungicide applied with a protectant fungicide on a 14-day schedule beginning after detecting powdery mildew at the action threshold, and, on alternate weeks, a DMI fungicide, Nova or Procure, applied with a protectant fungicide. If the proportion of isolates resistant to QoI fungicides remains below 50%, then additional applications of QoI fungicides are warranted. QoI resistance will be monitored using the bioassay in a commercial field of pumpkin where the recommended fungicide program is used.

Objectives:

1. Determine the proportion of the powdery mildew pathogen population that is resistant to QoI fungicides before the first application to main-season crops in three locations throughout New York.
2. Examine the impact of applying QoI fungicides on the proportion of the pathogen population that's resistant.
3. Assess project impact by conducting telephone interviews with growers after the growing season.

Procedures:

Additional funds obtained from Friends of Long Island Horticulture enabled more bioassays to be conducted in Suffolk County.

1. Prior to the growing season, vegetable growers were identified who were planning to grow an early crop of zucchini or yellow summer squash that will not be sprayed with QoI fungicides. Powdery mildew typically starts to develop late enough in early squash plantings that fungicide treatment is not warranted. These crops were scouted for powdery mildew beginning in mid July.

A seedling bioassay was used to determine the fungicide sensitivity of the powdery mildew fungal pathogen in cucurbit crops. Summer squash seedlings were grown in greenhouses or

growth chambers. Seedlings received 1 of 4 treatments: no fungicide, Flint (50 ppm), Nova (20 ppm), or a combination of both. First the growing point and unexpanded leaves were removed. Then they were dipped in the fungicide solutions, and allowed to dry overnight before setting in a cucurbit crop in groups of four plants with the four treatments. There were 2 to 7 groups per field. The concentration of Nova used was one of the highest concentrations tolerated in previous studies by at least a small proportion of isolates tested. Very few isolates have been found able to tolerate 80 ppm. Isolates able to tolerate 20 ppm Nova are considered to have a moderate level of DMI resistance. They are fully resistant to Bayleton, being associated with ineffective control with this DMI fungicide, and moderately resistant to Nova, being associated with good control at the highest label rate and reduced control at the lowest rate of Nova. After being in fields for 4 hours to overnight, seedlings were kept in a greenhouse until symptoms of powdery mildew were visible, which took at least one week. Then severity (percent tissue with symptoms) was visually estimated for each leaf. Frequency of resistant pathogen strains in a field was estimated by calculating the ratio of severity on fungicide-treated plants relative to non-treated plants for each group, then determining the field average.

Pumpkins were used for the seedling bioassay conducted in Ontario County. They were kept in a greenhouse at the NYS Agricultural Experiment Station in Geneva. The plants were set out in the field in six spots for 1 – 2 days depending on the severity of natural powdery mildew infection there.

Results and recommendations on fungicides were disseminated to growers throughout NY.

2. Pumpkin growers in Suffolk County with fields near the spring squash plantings and willing to cooperate were identified. The seedling bioassay was conducted after several fungicide applications were made. Powdery mildew severity was assessed.

3. Growers are being contacted by telephone to assess the impact of this project.

Results and Discussion:

Information from the fungicide sensitivity seedling bioassays, along with recommendations on how to modify fungicide programs, was provided to growers during the growing season through newsletter articles. Where resistance had developed, growers were able to avoid unnecessary applications of an expensive fungicide during the second half of the epidemic when QoI resistant strains were sufficiently common that QoI fungicides were unlikely to have been effective.

SUFFOLK COUNTY

The first seedling bioassay was conducted on 27 Jul in early plantings of summer squash and pumpkin where neither QoI or DMI fungicides had been applied yet this year. It revealed QoI resistance in 1 of 5 fields (61% frequency in that field) and low level of moderate DMI resistance in all fields (1 - 25% frequency)(Table 1).

Powdery mildew severity was assessed on 19-21 Aug in four commercial pumpkin fields where fungicide sensitivity was going to be monitored. Powdery mildew was much more severe on the lower surface of leaves than expected based on the fungicides being used. Average severity on upper leaf surfaces was 0.1%, 0%, 4%, and 0%, respectively, in these four fields; whereas on lower leaf surfaces severity was 5%, 11%, 11%, and 18%. Good control on upper leaf surfaces indicates application timing was good. Protectant fungicides (e.g. Bravo, copper) only work

where deposited, which is mostly the upper surface. Systemic fungicides provide most of the control on lower surfaces.

The second bioassay was conducted on 31 Aug to determine the level of resistance in commercial pumpkin fields and research plots at Cornell. In most fields there was little powdery mildew on upper leaf surfaces while lower surfaces were severely affected, and several leaves had died, likely due to poor control of powdery mildew. Nontreated seedlings became severely infected, with some leaves completely white due to powdery mildew, which revealed the large quantity of spores in the air. QoI resistance was detected in all 7 fields (61 – 100% frequency), including one field where Nova was used but not QoIs. Moderate DMI insensitivity was detected in all fields as well (12 – 56% frequency).

A third bioassay was conducted on 25 Sep to determine if resistant strains were sufficiently widespread on LI to be present where no QoI or DMI fungicides were used. Two of these 3 fields were being organically managed. QoI resistance was detected in these fields (2, 38, and 56% frequency) and also in the fields included in this bioassay where QoI and/or DMI fungicides had been used (88 - 97% frequency).

Powdery mildew severity on seedlings treated with Nova generally was similar to severity on seedlings treated with both Nova and Flint for each field, which suggests that most isolates moderately insensitive to DMIs were also resistant to QoIs. Almost all individual isolates tested in 2002 using a laboratory assay were either sensitive to both chemical groups or insensitive to DMIs and also resistant to QoIs.

In conclusion, strains of the powdery mildew fungus with resistance to QoI and/or DMI fungicides were present at a low level before these fungicides were used on Long Island in 2003. Frequency of resistant strains increased substantially when these fungicides were used. Resistance explains poor control observed on lower leaf surfaces in late Aug. Resistant strains were common at the end of the growing season, even occurring in crops not treated with QoI or DMI fungicides.

ONTARIO COUNTY

The first set of plants was put out in zucchini on plastic in the IPM (future) systems trial at the NYSAES, Geneva, on 18 Jul when powdery mildew was first detected in the area and when it was easy to find in the field. The field had been sprayed 3 days earlier with 5 oz/acre Nova and 1 qt/acre Bravo but it was the best one we could find at that time. They were left out two full days. No powdery mildew developed on any of the treatments over a 2 week period.

The second set of plants was put out in Pedersen's pumpkin field on Johnson Rd. on 5 Aug when powdery mildew was first detected there. The field had not yet been sprayed. The plants were left out just 24 hours since a storm was forecast. There was no sign of powdery mildew after 7 days. At 11 days the following was observed:

Untreated - 54 powdery mildew lesions

Nova - 8 lesion

Flint - 7 lesions

Because it took so long for disease to develop it may have been from infection that occurred after the plants were removed from the pumpkin field.

The third set of plants was set out in Pedersen's pumpkin field on Sutton Rd. on 26 Sept, four weeks after spraying had ceased and when the foliage was down due to powdery mildew and maturity.

Fungicide Sprays – Pedersen's Sutton Rd. Pumpkin Field

7/29 Flint 2 oz/A; Bravo 1 1/2 pt/A
8/8 Nova 4 oz/A; Microsulf 2 lbs/A
8/18 Flint 2 oz/A; Bravo 1 1/2 pt/A
8/28 Nova 4 oz/A; Microsulf 2 lbs/A

Plants were left out just 24 hours. After field exposure the plastic bags were removed from the pots from the trials on all three dates and they were placed in a partially enclosed porch.

The following data was collected after 9 days:

Untreated - 83 lesions, concentrated on 2 plants, from the same part of the field
Nova - 1 lesion
Flint - 4 lesions

On both dates and on all treatments lesions occurred more on the upper surface than the lower surface of leaves.

Powdery mildew control was satisfactory in this area this year where growers applied fungicides to control it. There was plenty of powdery mildew present by the end of the season, however.

LAKE PLAINS REGION

In mid-July the bioassay was conducted in two different squash fields, using Flint applied to pumpkin seedlings, to try and determine if there were any QoI resistant powdery mildew strains in the area. Powdery mildew did not develop on any of these seedlings, suggesting that the test was conducted when there were too few spores in the air.

QoI resistant powdery mildew strains were present in Western NY. There was a powdery mildew fungicide study conducted at the New York Crop Research Facility in Batavia. One of the treatments was a weekly spray with the QoI fungicide Quadris and another was a weekly spray with Cabrio, another QoI fungicide. At the end of the trial powdery mildew could be found easily on the leaves that received either of these strobilurins. The growers in this area have not been surveyed but most of them are probably using one of the following options to control powdery mildew. Use the recommended spray program of Flint or Quadris alternated with Nova + Bravo or spraying with Bravo and using Quadris or Flint if control is not being achieved with Bravo alone.

In 2003, there were no complains in Western NY about the apparent failure of Flint or Quadris. It appears that resistant strains are not yet a problem in Western NY.

CAPITAL DISTRICT

There were no complains of control failure with QoI fungicides in the Capital District. Growers in this area are using more systemic fungicides now as they seem to have a better understanding of the role of these materials in achieving effective control from articles in newsletters and presentations given at grower meetings.

CONCLUSIONS

The fungicide sensitivity seedling bioassay proved to be a useful tool for monitoring resistance in cucurbit production fields. It is much easier and less costly to perform than the standard laboratory assay done with individual isolates, results are obtained more quickly, and a larger portion of the population can be examined. The only potential difficulty is finding greenhouse space to keep the seedlings in. This technique could not easily be done by most growers; it is intended for use by researchers, extension staff, and consultants. Implementing this bioassay could result in reduced pesticide usage when it reveals high frequency of fungicide resistant strains, as occurred in 2003 on Long Island.

References:

1. McGrath, M. T. 2001. Fungicide resistance in cucurbit powdery mildew: Experiences and challenges. *Plant Disease* 85(3): 236-245. (Feature article).
2. McGrath, M. T., and Shishkoff, N. 2001. Resistance to triadimefon and benomyl: dynamics and impact on control of cucurbit powdery mildew. *Plant Disease* 85(2):147-154.

Table 1. Frequency of cucurbit powdery mildew fungal isolates that were moderately resistant to DMI fungicides and frequency of isolates that were resistant to QoI fungicides based on results of a fungicide sensitivity seedling bioassay. These isolates were detected at 11 sites on Long Island, including Cornell University's Long Island Horticultural Research and Extension Center. The sites are numbered based on location beginning with the western most site which was in Wading River. The DMI fungicide Nova was the only systemic fungicide used at site 3. Only protectant fungicides were used at site 10. No fungicides were used at sites 7 and 9 which were under organic production.

Site	DMI Moderately Resistant isolates (%)			Strobilurin (QoI) Resistant isolates (%)		
	7/27	8/31	9/25	7/27	8/31	9/25
1		33			61	
2	1	13		0	100	
Cornell	16	56		0	100	
3 (no QoI fungicides)		44	5		83	88
4	6	56		61	91	
5		12	1		89	89
6	25			0		
7 (Organic)			1			2
8		35	1		97	97
9 (Organic)			1			56
10 (no systemics)	17		1	0		38